APPENDIX XI:

UNCONFINED COMPRESSION TEST

1. INTRODUCTION. The unconfined compression test is used to measure the unconfined compressive strength of a cohesive soil. The unconfined compression test is applicable only to coherent materials such as saturated clays or cemented soils that retain intrinsic strength after removal of confining pressure; it is not a substitute for the Q test. Dry or crumbly soils, fissured or varved materials, silts, and sands cannot be tested meaningfully in unconfined compression. in this test, a laterally unsupported cylindrical specimen is subjected to a gradually increased axial compression load until failure occurs. The unconfined compression test is a form of triaxial test in which the major principal stress is equal to the applied axial stress, and the intermediate and minor principal stresses are equal to zero. The unconfined compressive strength, q_u, is defined as the maximum unit axial compressive stress at failure or at 15 percent strain, whichever occurs first. The undrained shear strength, s_u, is assumed to be equal to one-half the unconfined compressive strength. The axial load may be applied to the specimen either by the controlled strain procedure, in which the stress is applied to produce a predetermined rate of strain, or by the controlled stress procedure, in which the stress is applied in predetermined increments of load.

2. APPARATUS. The apparatus consists of the following:

a. Equipment for Preparing Specimen. A trimming frame as described% paragraph 3e of Appendix X, TRIAXIAL COMPRESSION TESTS, or a trimming cylinder with beveled cutting edges may be used for trimming specimens. The equipment should include wire saws and knives of various sizes and types for use with the trimming frame. A motorized soil lathe may be used advantageously under certain circumstances. A miter box or cradle is required to trim the specimen to a fixed length and to ensure that the ends of the specimen are parallel with each other and perpendicular to the vertical axis of the specimen.

b. Loading Device. A number of commercially available controlled-strain or controlled-stress types of loading devices are suitable for applying the axial loads in the unconfined compression test. In

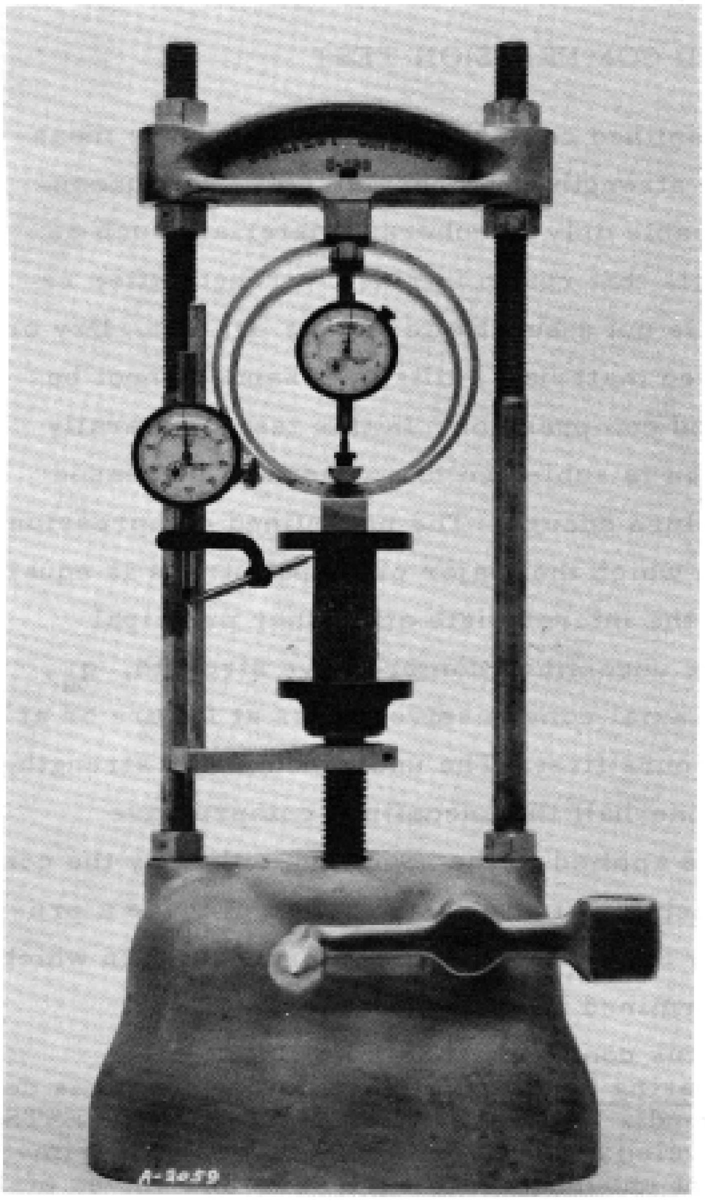

Figure 1. Typical unconfined compression test apparatus

general, controlled-strain type loading devices are preferable, and the procedures described herein are based on the use of this type of equipment. If available, an automatic stress-strain recorder may be used to measure and record applied axial loads and displacements. A typical loading device is shown in Figure 1. Any equipment used should be calibrated so that the loads actually applied to the soil specimen can be determined. The required sensitivity of stress-measuring equipment for both controlled-stress and controlled-strain testing will vary with the strength characteristics of the soil. For relatively weak soils (compressive strengths less than 1.0 ton per sq ft), the unit load should be measurable to within 0.01 ton per sq ft. For soils with compressive strengths of 1.0 ton per sq ft or greater, the loads should be measurable to the nearest 0.05 ton per sq ft.

c. Measuring equipment, such as dial indicators and calipers, suitable for measuring the dimensions and axial deformation of a specimen to the nearest 0.001 in.

d. Timing device, either a watch or clock with second hand.

e. Balances, sensitive to 0.1 g.

f. Other. Apparatus necessary to determine water content and specific gravity (see Appendixes I, WATER CONTENT - GENERAL, and IV, SPECIFIC GRAVITY).

3. PREPARATION OF SPECIMENS. a. Specimen Size. Unconfined compression, specimens shall have a minimum diameter of 1.0 in. (preferably 1.4 in.), and the largest particle in any test specimen will be no greater than one-sixth the specimen diameter. The height-to-diameter ratio shall be not less than 2.1. Commonly used diameters of unconfined compression specimens are 1.4 and 2.8 in. Specimens of 1.4-in. diameter are generally used for testing cohesive soils which contain a negligible amount of gravel.

b. Undisturbed Specimens. Generally, undisturbed specimens are prepared from undisturbed tube or chunk samples of a larger size than the test specimen. Core or thin-wall tube samples of relatively small diameter may be tested without further trimming except for squaring the ends, if the condition of the soil requires this procedure. Specimens must be handled carefully to prevent remolding, changes in cross section, or loss of moisture. To minimize disturbance caused by skin friction between samples and metal sampling tubes, the tubes should be cut into short lengths before ejecting the samples. Sample ejection should be accomplished with a smooth continuous, and fairly rapid motion in the same direction that the sample entered the tube. All specimens shall be prepared in a humid room to prevent evaporation of moisture. The specimen shall be prepared as follows:

(1) From the undisturbed sample cut a section somewhat larger in length and diameter than the desired specimen size.

It is generally desirable to prepare duplicate specimens for unconfined compression testing, and selection of material for testing should be made with this in mind.

(2) Carefully trim the specimen to the required diameter using a trimming frame and various trimming tools (see Fig. 7, Appendix X, TRIAXIAL COMPRESSION TESTS). Remove any small shells or pebbles encountered during the trimming operations. Carefully fill voids on the surface of the specimen with remolded soil obtained from the trimmings. Cut the specimen to the required length, using a miter box (see Fig. 8, Appendix X, TRIAXIAL COMPRESSION TESTS). Where the presence of pebbles or crumbling results in excessive irregularity at the ends, cap the specimens with a minimum thickness of plaster of Paris, hydrostone, or other support material. Care must be taken to insure that the ends of the specimen are parallel with each other and perpendicular to the vertical axis of the specimen.

(3) From the soil trimmings obtain 200 g of material for specific gravity and water content determinations (see Appendixes I, WATER CONTENT - GENERAL, and IV, SPECIFIC GRAVITY).

(4) Weigh the specimen to an accuracy of ±0.01 g for 1.4-in.-diameter specimens and ±0.1 g for 2.8-in.-diameter specimens. If specimens are to be capped, they should be weighed before capping.

(5) Measure the height of the specimen with calipers or a scale and the diameter with calipers or circumference measuring devices. If the specimen is cut to a fixed length in a miter box, the length of the miter box can be taken as the height of specimen for routine tests, and additional height measurements are not usually necessary. It is always advisable to measure the diameter of the specimen after trimming, even though specimens are cut to a nominal diameter in a trimming frame. Make all measurements to the nearest ±0.01 in. Determine the average initial diameter, D_o, of the specimen using the diameters measured at the top, D_t, center, D_c, and bottom, D_b, of the specimen, as follows:

$$D_o = \frac{D_t + 2D_c + D_b}{4}$$

(6) If the specimen is not tested immediately after preparation, precautions must be taken to prevent drying and consequent development of capillary stresses. When drying before or during the test is anticipated, the specimen may be covered with a thin coating of grease such as petrolatum. This coating cannot be used if the specimen is to be used in a subsequent remolded test.

c. Remolded Specimens. Remolded specimens usually are prepared in conjunction with tests made on undisturbed specimens after the latter has been tested to failure. The remolded specimens are tested to determine the effects of remolding on the shear strength of the soil. The remolded specimen should have the same water content as the undisturbed specimen in order to permit a comparison of the results of the tests on the two specimens. The remolded specimen shall be prepared as follows:

(1) Place the failed undisturbed specimen in a rubber membrane and knead it thoroughly with the fingers to assure complete remolding of the specimen. Take reasonable care to avoid entrapping air in the specimen and to obtain a uniform density.

(2) Remove the soil from the membrane and compact it in a cylindrical mold with inside dimensions identical with those of. the undisturbed specimen. The compaction effort is not critical since the water contents of soils subjected to remolded tests are always considerably wetter than optimum. Care must be taken, however, to insure uniform density throughout the specimen. A thin coat of petrolatum on the inside of the molding cylinder will assist in the removal of the specimen after compaction.

(3) Carefully remove the specimen from the mold, preferably by means of a close fitting piston, and plane off the top of the specimen. The specimen is then ready for testing.

(4) Follow the steps outlined in paragraphs 3b(4) and 3b(5).

4. PROCEDURE. The procedure shall consist of the following steps:

a. Record all identifying information for the sample such as project, boring number, visual classification, and other pertinent data on the data sheet (see Plate XI-1 which is a suggested form). The data sheet is also used for recording test observations described below.

b. Place the specimen in the loading device so that it is centered on the bottom platen; then adjust the loading device carefully so that the loading ram or upper platen barely is in contact with the specimen. If a proving ring is used for determining the axial load, contact of the platen and specimen is indicated by a slight deflection of the proving ring dial. Attach a dial indicator, sensitive to 0.001 in., to the loading ram to measure vertical deformation of the specimen. Record the initial reading of the dial indicator on the data sheet (Plate XI-1). Test the specimen at an axial strain rate of about 1 percent per minute. For very stiff or brittle materials which exhibit small deformations at failure, it may be desirable to test the specimen at a slower rate of strain.. Observe and record the resulting load corresponding to increments of 0.3 percent strain for the first 3 percent of strain and in increments of 1 or 2 percent of strain thereafter. Stop the test when the axial load remains constant or when 20 percent axial strain has been produced.

c. Record the duration of the test, in minutes, to peak strength (time to failure), type of failure (shear or bulge), and a sketch of specimen after failure on the data sheet (Plate XI-2).

d. After the test, place the entire specimen or a representative portion thereof in a container of known weight and determine the water content of the specimen in accordance with Appendix I, WATER CONTENT - GENERAL.

5. COMPUTATIONS. The computations consist of the following steps:

a. From the observed data, compute and record on the data sheet (Plate XI-1) the water content, volume of solids, void ratio, degree of saturation, and dry density, using the formulas presented in Appendix II, UNIT WEIGHTS, VOID RATIO, POROSITY, AND DEGREE OF SATURATION.

b. Compute and record on the data sheet the axial strain, the corrected area, and the compressive stress, at each increment of strain by using the following formulas:

$$\text{Axial strain, } \varepsilon = \frac{\Delta H}{H_o}$$

$$\text{Corrected area of specimen, } A_{corr}, \text{ sq cm} = \frac{A_o}{1 - \varepsilon}$$

$$\text{Compressive stress, tons per sq ft} = \frac{P}{A_{corr}} \times 0.465$$

where

ΔH = change in height of specimen during test, cm

H_o = initial height of specimen, cm

A_o = initial area of specimen, sq cm

P = applied axial load, lb

6. **PRESENTATION OF RESULTS.** The results of the unconfined compression test shall be recorded on the report form shown as Plate XI-2. Pertinent information regarding the condition of the specimen, method of preparing the specimen, or any unusual features of each specimen (such as slickensides, stratification, shells, pebbles, roots, or brittleness) should be shown under "Remarks." The applied compressive stress shall be plotted versus the axial strain in Plate XI-2. The unconfined compressive strength, q_u, of the specimen shall be taken as the maximum or peak compressive stress. For tests continued to 20 percent strain without reduction of axial load occurring, the unconfined compressive strength as a rule shall be taken as the compressive stress at 15 percent strain.

Where the unconfined compressive strength of a specimen is also obtained after remolding, the sensitivity ratio, S_t, shall also be calculated and reported. The sensitivity ratio is defined as follows:

$$S_t = \frac{q_u \text{ (undisturbed)}}{q_u \text{ (remolded)}}$$

-7. POSSIBLE ERRORS. Following are possible errors that would cause inaccurate determinations of unconfined compressive strength:

a. Test not appropriate to type of soil.

b. Specimen disturbed while trimming.

c. Loss of initial water content. A small change in water content can cause a larger change in the strength of a clay, so it is essential that every care be taken to protect the specimen against evaporation while trimming and measuring, during the test, and when remolding a specimen to determine the sensitivity.

d. Rate of strain or rate of loading too fast.

a. USE OF OTHER TYPES OF EQUIPMENT FOR UNDRAINED SHEAR STRENGTH DETERMINATIONS. Various other types of laboratory equipment, such as cone penetrometers and vane shear apparatus, may be used advantageously in the laboratory as a supplement to the basic unconfined compression test equipment for determining the undrained shear strength of cohesive soils. The use of these testing devices generally results in savings in cost and time. However, the devices should be used with caution until sufficient data and procedural details are established to assure their successful application. Use of such testing apparatus, as a rule, should be preceded by careful correlations with the results of tests with the basic unconfined compression test equipment on the same type of soil, and correlations developed for a given type of soil should not be used indiscriminately for all soils.

UNCONFINED COMPRESSION TEST

Date ____________

Project ____

Boring No. ____________________ Sample No. ____________________

Specimen No.			Classification				
Tare No.			Height	H_o	in.	H_o	cm
Weight, g	Tare plus wet specimen		Average diameter	D_o	in.	D_o	cm
	Tare plus dry specimen		Initial area	A_o	sq in.	A_o	sq cm
	Water W_w		Volume in cc = A_oH_o			V_o	
	Tare		Volume of solids in cc = $W_s \div G_s$			V_s	
	Wet specimen W		Void ratio = $(V_o - V_s) \div V_s$			e_o	
	Dry specimen W_s		Saturation in % = $G_s w_o \div e_o$			S_o	%
Water content w_o		%	Dry dens., lb/cu ft = $62.4\ (W_s \div V_o)$			γ_d	
Specific gravity of solids G_s							

Note: If only a portion of the specimen is used for the water content determination, $W_s = W \div \left(1 + \frac{w_o}{100}\right)$

Elapsed Time min	Dial Reading 10^{-} in.	Cumulative Change, ΔH 10^{-} in.	Proving Ring Dial Reading 10^{-} in.	Axial Load, P lb	Axial Strain $\epsilon = \Delta H/H_o$	$1 - \epsilon$	$A_{corr} = A_o/(1-\epsilon)$ sq cm	Compr Stress tons/sq ft $0.465(P/A_{corr})$

Remarks ____

____________________________ Type Failure ____________

Technician ____________ Computed by ____________ Checked by ____________

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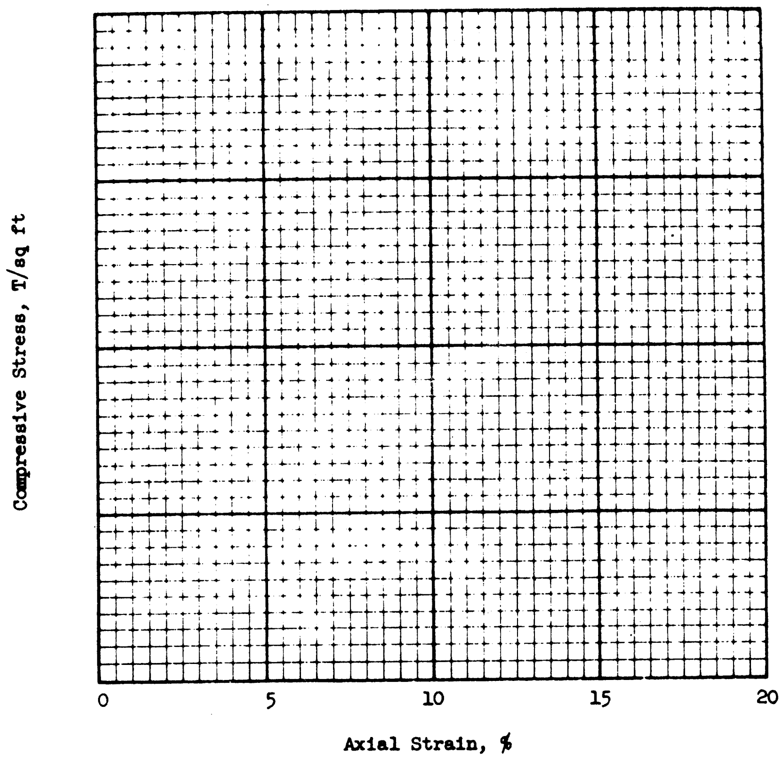
Failure Sketches



☐ Controlled stress

☐ Controlled strain

Test No.						
Type of specimen						
Initial	Water content	w_o	%	%	%	%
Initial	Void ratio	e_o				
Initial	Saturation	S_o	%	%	%	%
Initial	Dry density, lb/cu ft	γ_d				
Time to failure, min		t_f				
Unconfined compressive strength, T/sq ft		q_u				
Undrained shear strength, T/sq ft		s_u				
Sensitivity ratio		S_t				
Initial specimen diameter, in.		D_o				
Initial specimen height, in.		H_o				

Classification			
LL	PL	PI	G_s

Remarks	Project	
	Area	
	Boring No.	Sample No.
	Depth El	Date
	UNCONFINED COMPRESSION TEST REPORT	

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PLATE XI-2